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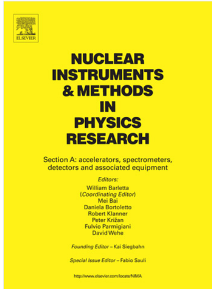

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Neutron beam profilometer on the base of double-sided silicon strip detectors

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Abstract

At present, in the Joint Institute for Nuclear Research (JINR), Dubna, Russia, experiments to study the process of inelastic scattering of fast neutrons with the nuclei of various substances are being conducted in the frame of the TANGRA (TAgged Neutron and Gamma RAys) project.

The existing TANGRA facility allows to obtain precise information about the angular and energy distributions of gamma-rays resulting from the inelastic scattering of 14.1 MeV neutrons on complex nuclei.

As source of neutrons, we used a portable neutron generator ING-27 (E_n=14.1 MeV), designed and created by VNIIA (Moscow) with an embedded double-sided 64-pixel silicon (gallium arsenide) alpha-particle detector, by means of which 64 independent tagged neutron beams are formed.

Tagging of neutrons is done by registration of the alpha particle, produced in the binary reaction d + t → (α + n), which is emitted in direction almost opposite to that of the neutron.

To obtain correct information about the characteristics of the process of inelastic neutron scattering on nuclei, it is necessary to know the parameters of all 64 tagged neutron beams with good accuracy.

To solve this problem, we have developed and created a two-coordinate position-sensitive silicon detector of fast neutron (profilometer), by means of which we measured the characteristics of all the 64 tagged neutron beams.

In this paper we give a description of the design of the profilometer and present the results from the measurements of profiles of 64 tagged neutron beams formed by ING-27.

Keywords: Silicon strip detectors; Fast neutrons; Tagged neutrons and gamma rays;TANGRA.

1. Introduction

For detailed study of the inelastic scattering of neutrons with energy of 14.1 MeV on complex nuclei, within TANGRA project (TAgged Neutron and Gamma RAys), in 2014 an installation «TANGRA» was designed and created at the Joint Institute for Nuclear Research (Dubna, Russia) [1, 2].

The operation of the TANGRA facility is based on the use of the tagged neutron method (TNM), the essence of which consists in recording the characteristic radiation (gamma-quanta, neutrons) from the inelastic scattering reactions of 14.1 MeV fast neutrons on the nuclei A of the substance, A(n, n'γ)A, in coincidence with the α particle, formed in the following neutron producing reaction:

$$d + {}^3H \rightarrow {}^4He\ (3.5\ MeV) + n\ (14.1\ MeV) \quad (1).$$

Here, the kinetic energy of the incident deuteron beam on the tritium target is ~ 80 - 100 keV. The α-particle and neutron are emitted nearly in opposite directions and therefore, by recording the direction of the α-particle, using a multi-pixel alpha detector mounted inside the neutron generator, it is possible to determine with good accuracy the direction of the neutron.

For a precise measurement of the angular distribution of the characteristic gamma radiation produced as a result of the inelastic scattering of fast neutrons on complex nuclei, one must have an unambiguous information about the spatial distribution of the tagged neutron beams incident on the investigated material.

One current practice for obtaining information about the tagged neutron beams in the XY plane of the detector perpendicular to their direction of propagation consists in using a number of mutually parallel light protected scintillation strips (1D-profilometer) [3].

Using the coincidence of signals from one of the alpha-detector pixels inside the neutron generator with one of the profilometer scintillation strips, it is possible to obtain information about the profile of each of the tagged neutron beams along the X or Y axes.

Thus, to get the 2D distribution of the neutron beams in the XY plane, it is necessary to make two individual measurements with mutually perpendicular orientations of the 1D-profilometer relative to the direction of the tagged neutron beams.

The main disadvantages of this design of the profilometer are as follows: